Introduction to solar thermal technology

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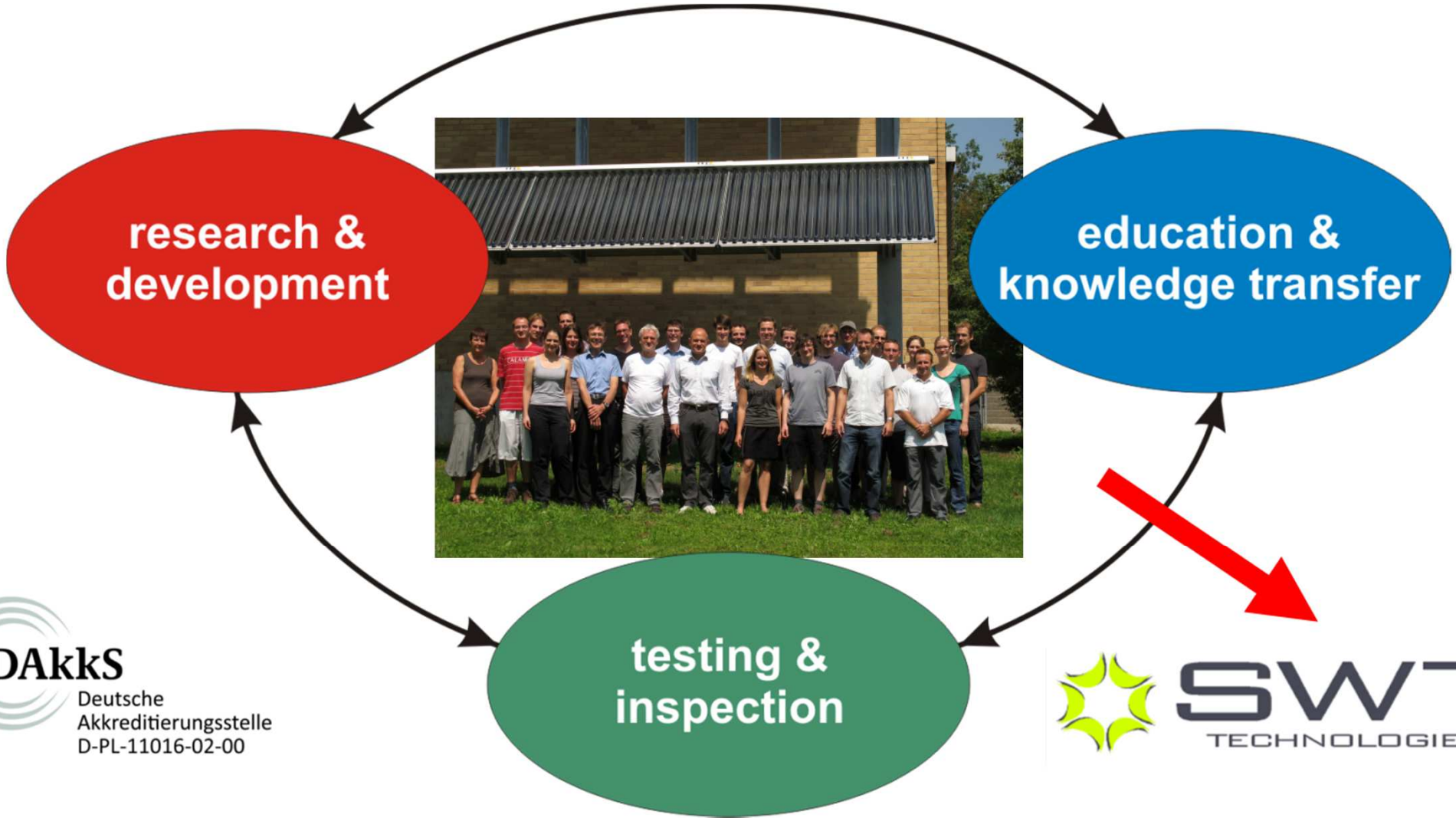
Content

- Presentation of ITW and TZS
- Background informations
- Solar thermal collectors
- Solar thermal systems
- Summary and conclusions

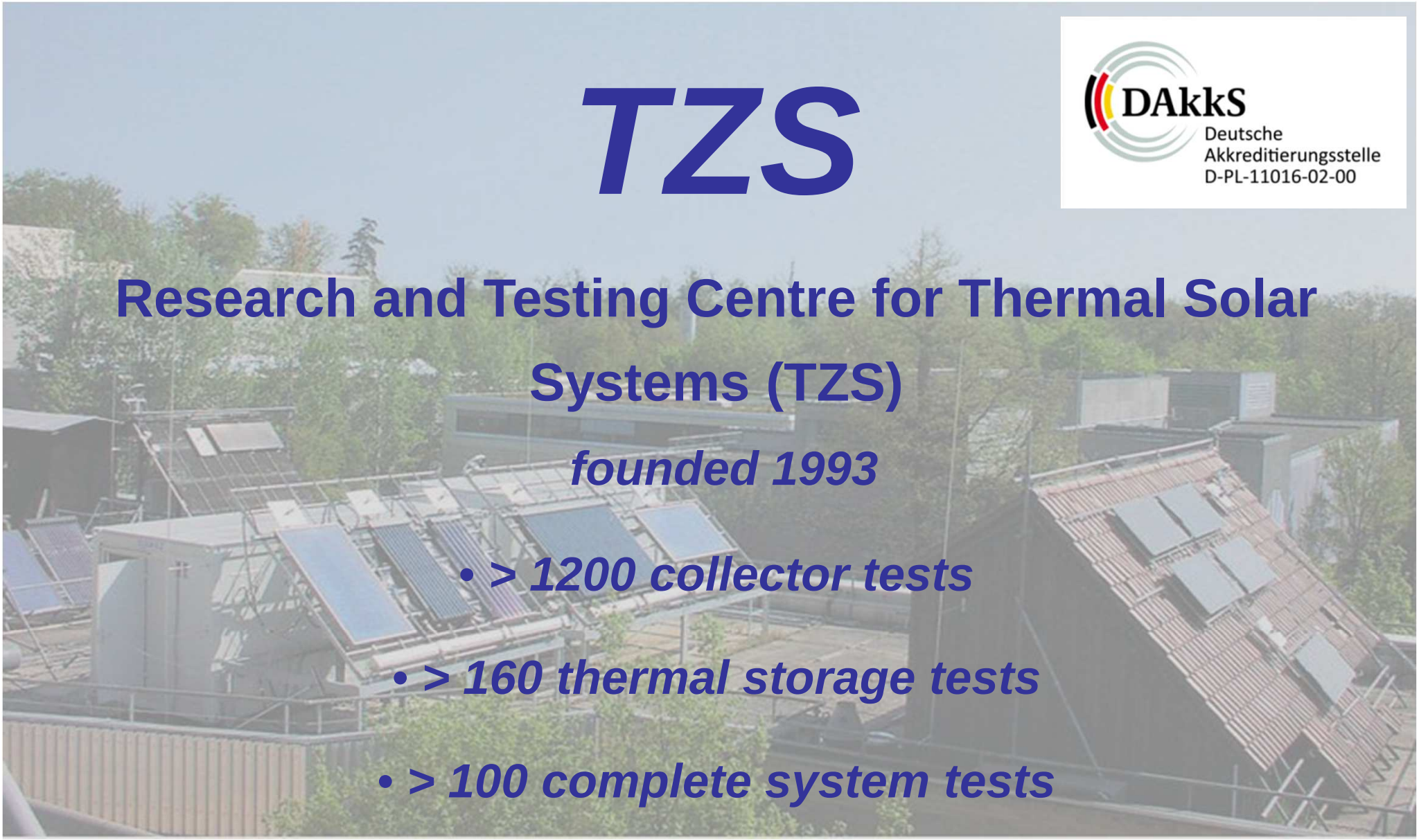
TZS

the largest testing centre and the largest university based research centre for thermal solar technology in Europe



DAkkS Deutsche Akkreditierungsstelle D-PL-11016-02-00

SWT TECHNOLOGIE



TZS

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Research and Testing Centre for Thermal Solar Systems (TZS)

founded 1993

- *> 1200 collector tests*
- *> 160 thermal storage tests*
- *> 100 complete system tests*

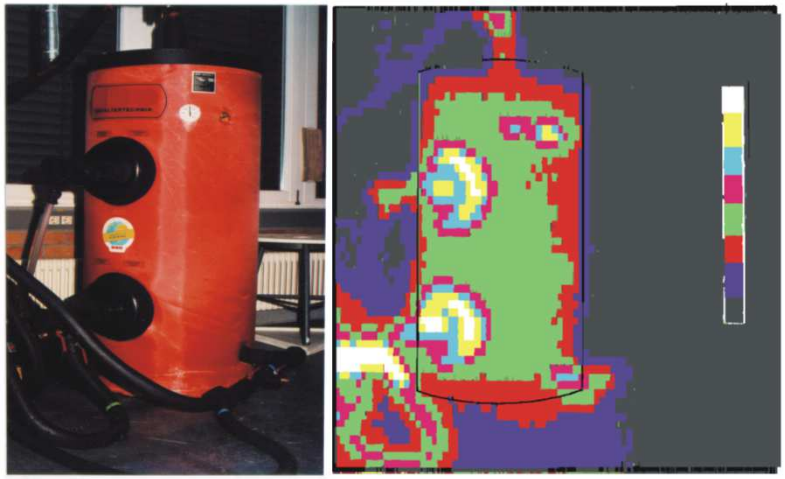
Collector Tests

- **outdoor tests**
- **indoor tests (solar simulator)**
- **performance prediction**

approximately half Solar Keymark tests up to now are from us

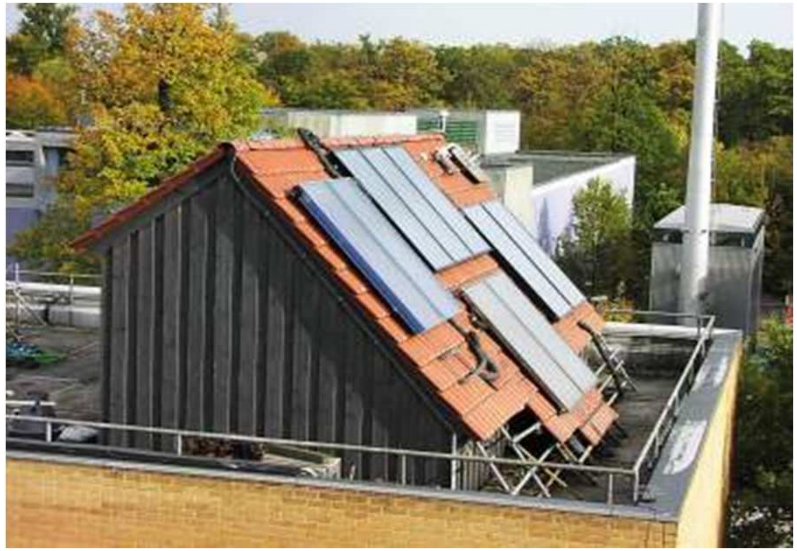
Reliability and Durability

- rain penetration
- high temperature resistance
- internal pressure for absorber
- mechanical load
- etc.



Store Tests

- hot water stores
- combi stores
- thermal store parameters



System Tests

- ISO 9459-2 (CSTG)
- ISO 9459-5 (DST)
- EN 12977 (Combi-Sys)
- system parameters
- performance prediction

Solar Keymark Testing

Complete solar collector and system test facility

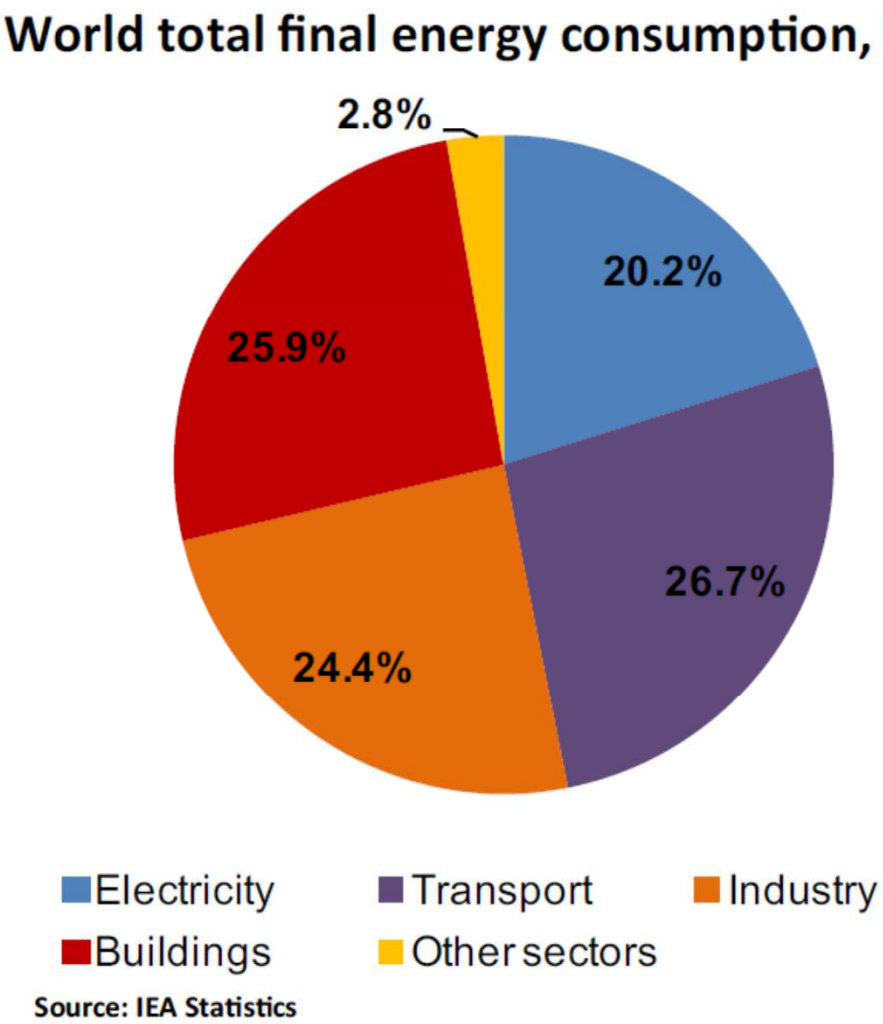
SWT TECHNOLOGIE

R&D activities

- Advanced energy concepts for solar buildings
- Thermochemical energy stores
- New solar collector designs
- Solar assisted district heating with seasonal heat stores
- Cooperation with several organisations (IEA SHC etc.)
- Consultancy and service projects
- and many more…

Background Information

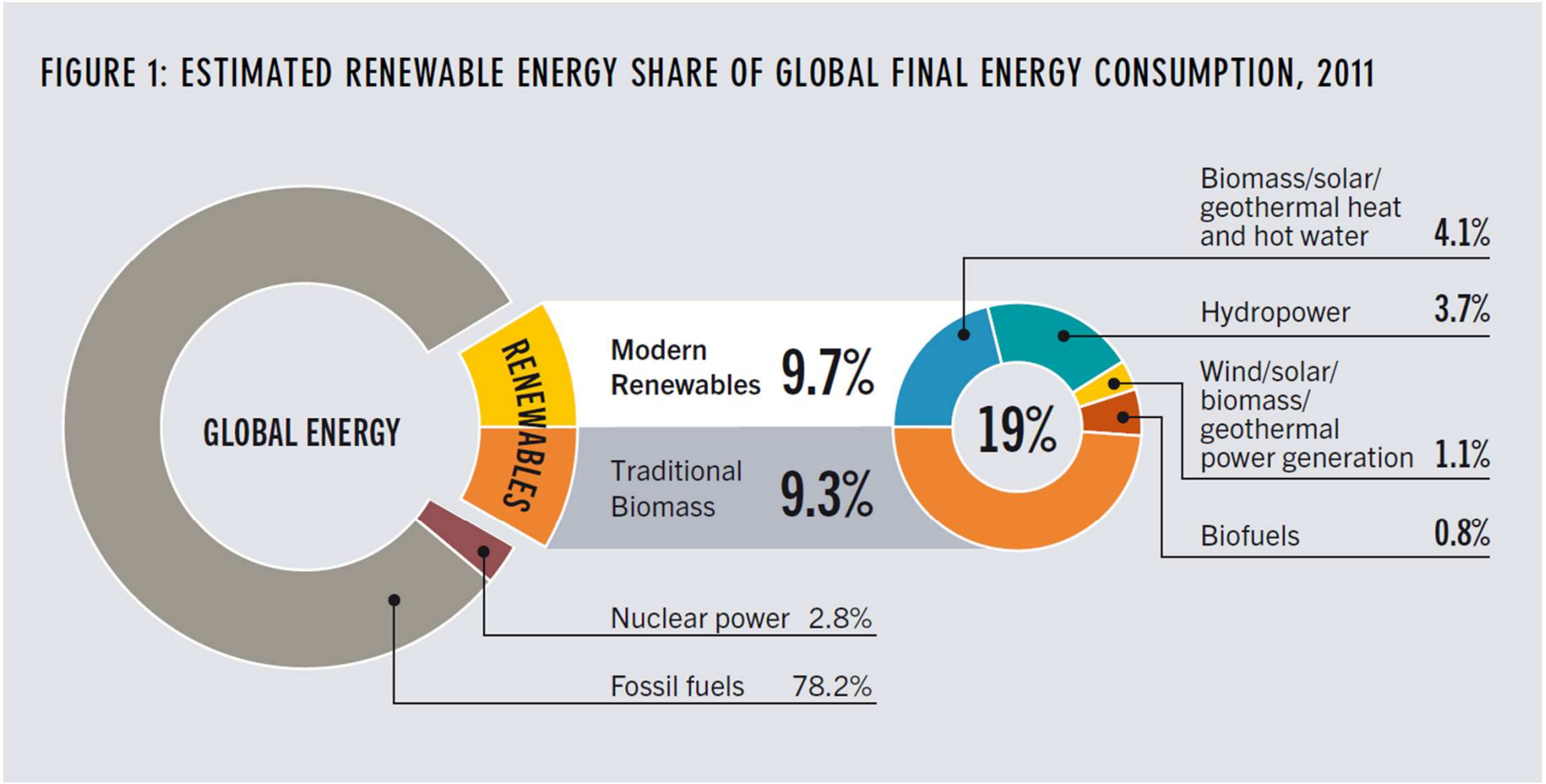
Global energy demand



more than 50 % of the demand is heat

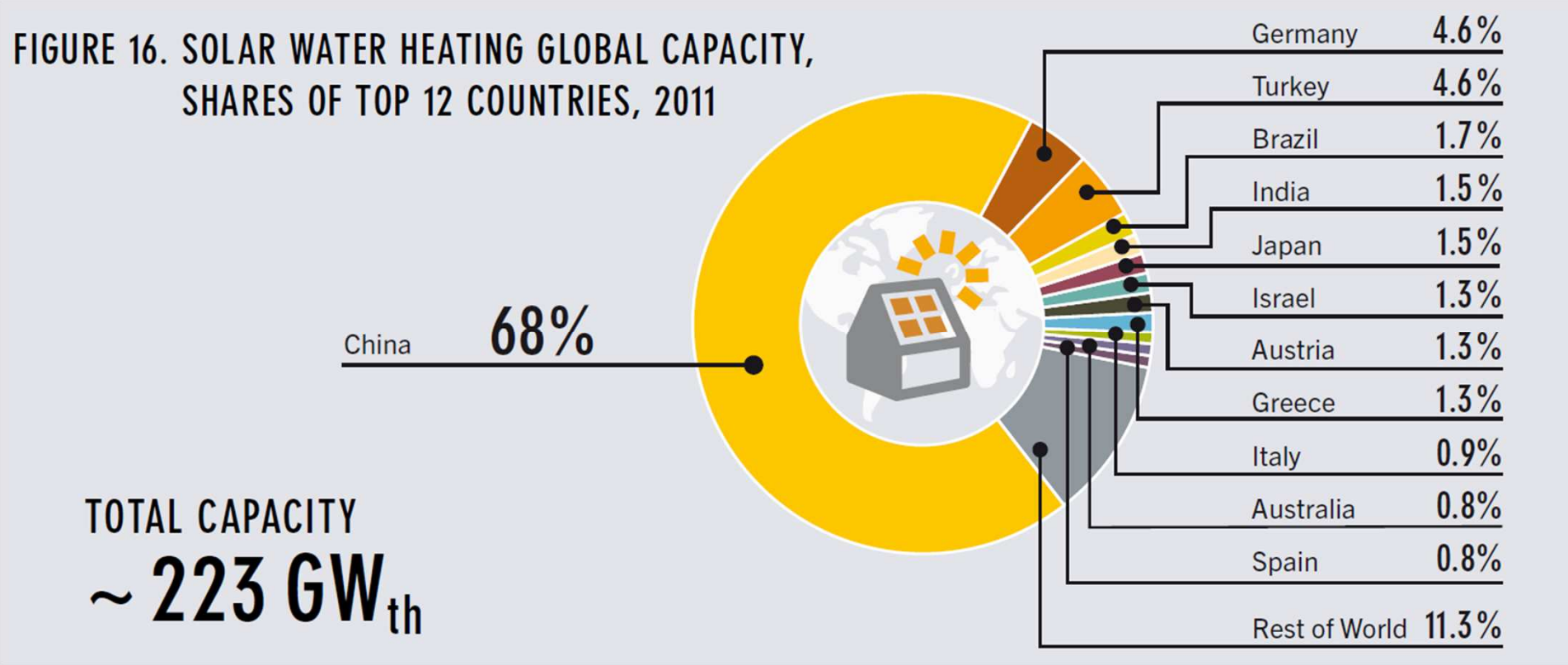
Source: IEA, P. Frankl, presentation 2013

Global energy production



Source: REN21, Renewables 2013

Globally installed solar thermal capacity

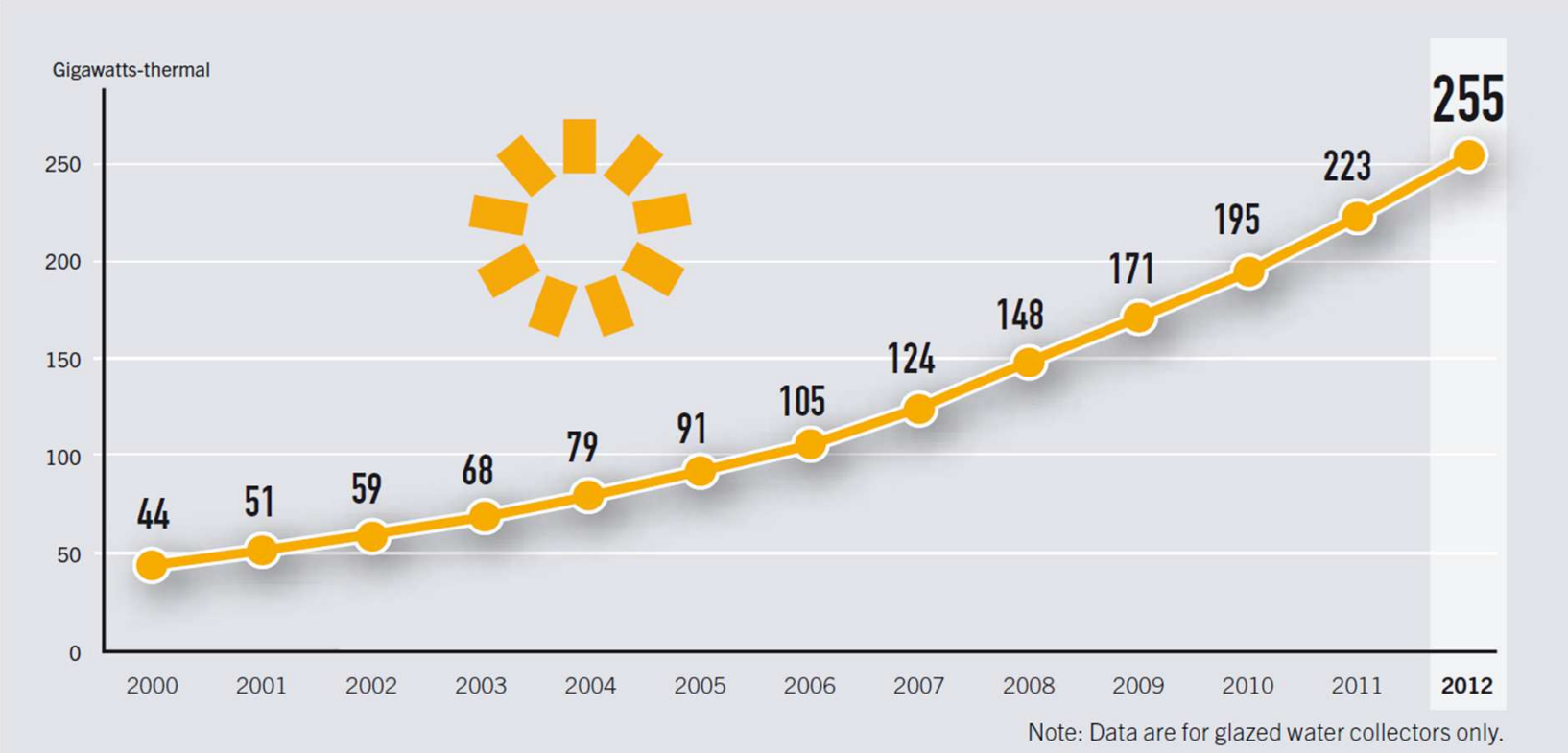


Source: REN21, Renewables 2013

These 223 GWth provided prox. 193 TWh of heat

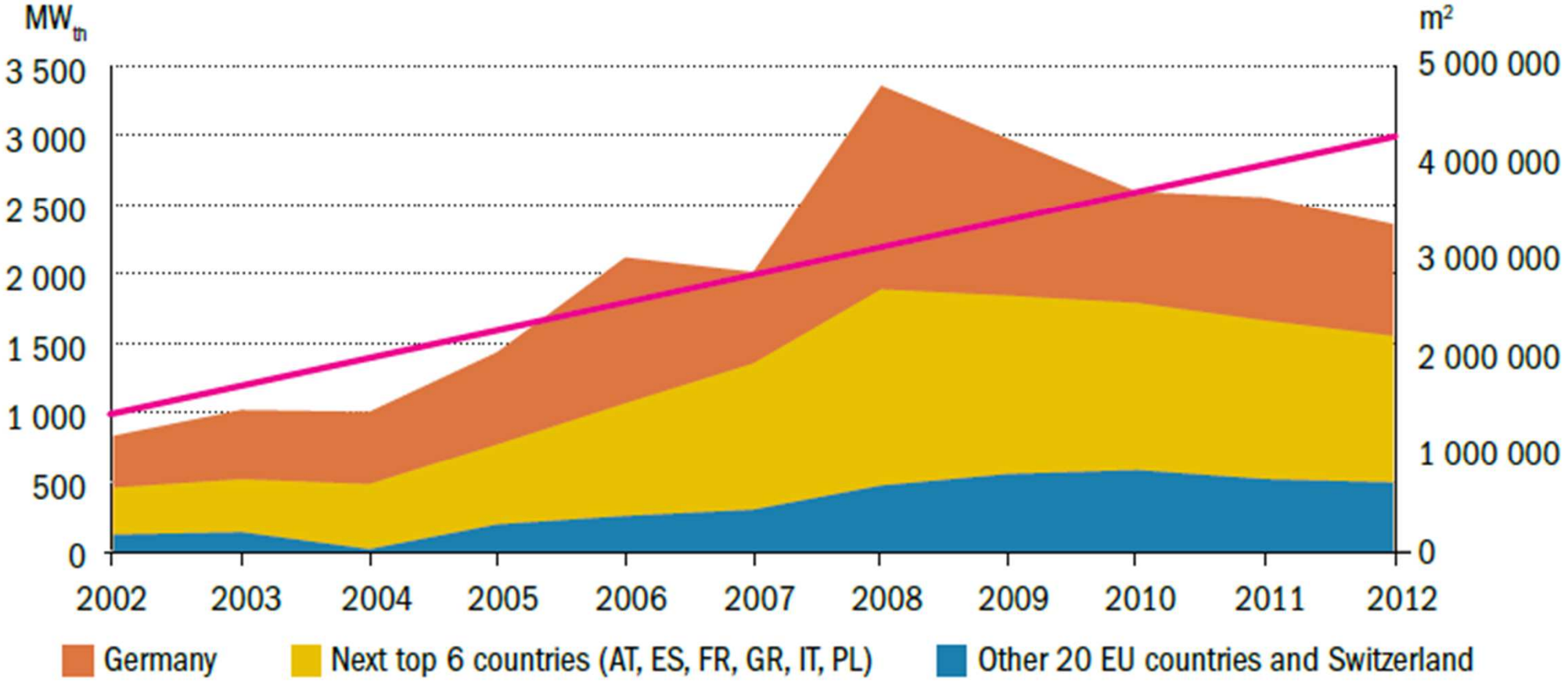
223 GWth ≈ 318 km² collectors

Globally installed solar thermal capacity



Source: REN21, Renewables 2013

European Solar Thermal Market Development (installations per year)



Source: ESTIF 2013

Applications of solar thermal energy

- Pool heating systems
- Solar thermal domestic hot water systems
- Systems for domestic hot water and space heating (combi systems)
- Solar district heating systems (seasonal heat storage)
- Solar cooling systems
- Solar process heat

Solar Thermal Collectors

A technology overview

Unglazed collectors

Pool Heating

Unglazed collectors

- mostly non-selective Absorber
- mostly polymeric material
- no glass cover (unglazed)
- no thermal insulation
- high optical efficiency
- high thermal losses
- range of operation 10 – 40°C

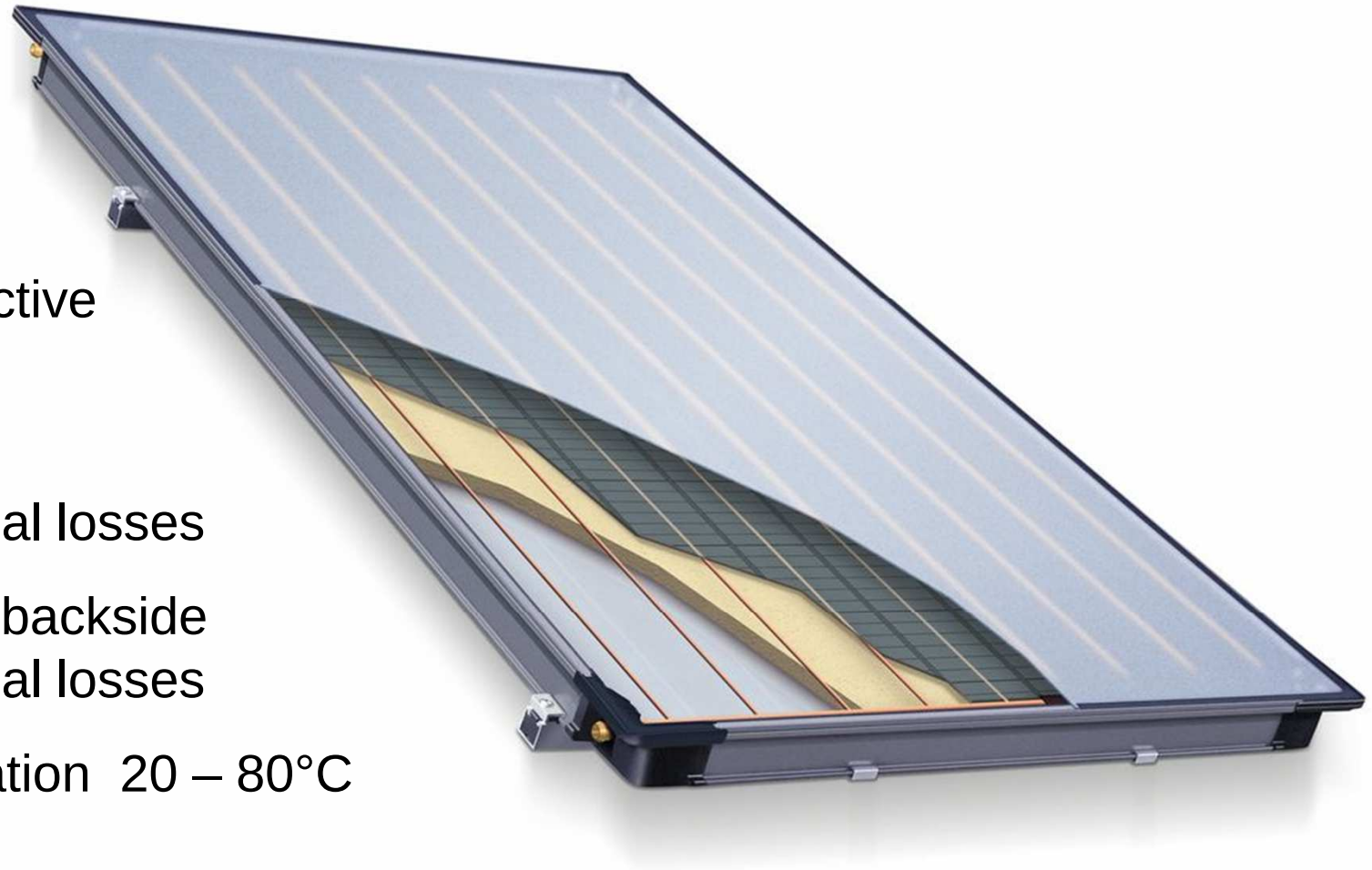
Source: fafco.com

Glazed collectors

Flat plate collectors and vacuum tube collectors

Flat plate collectors

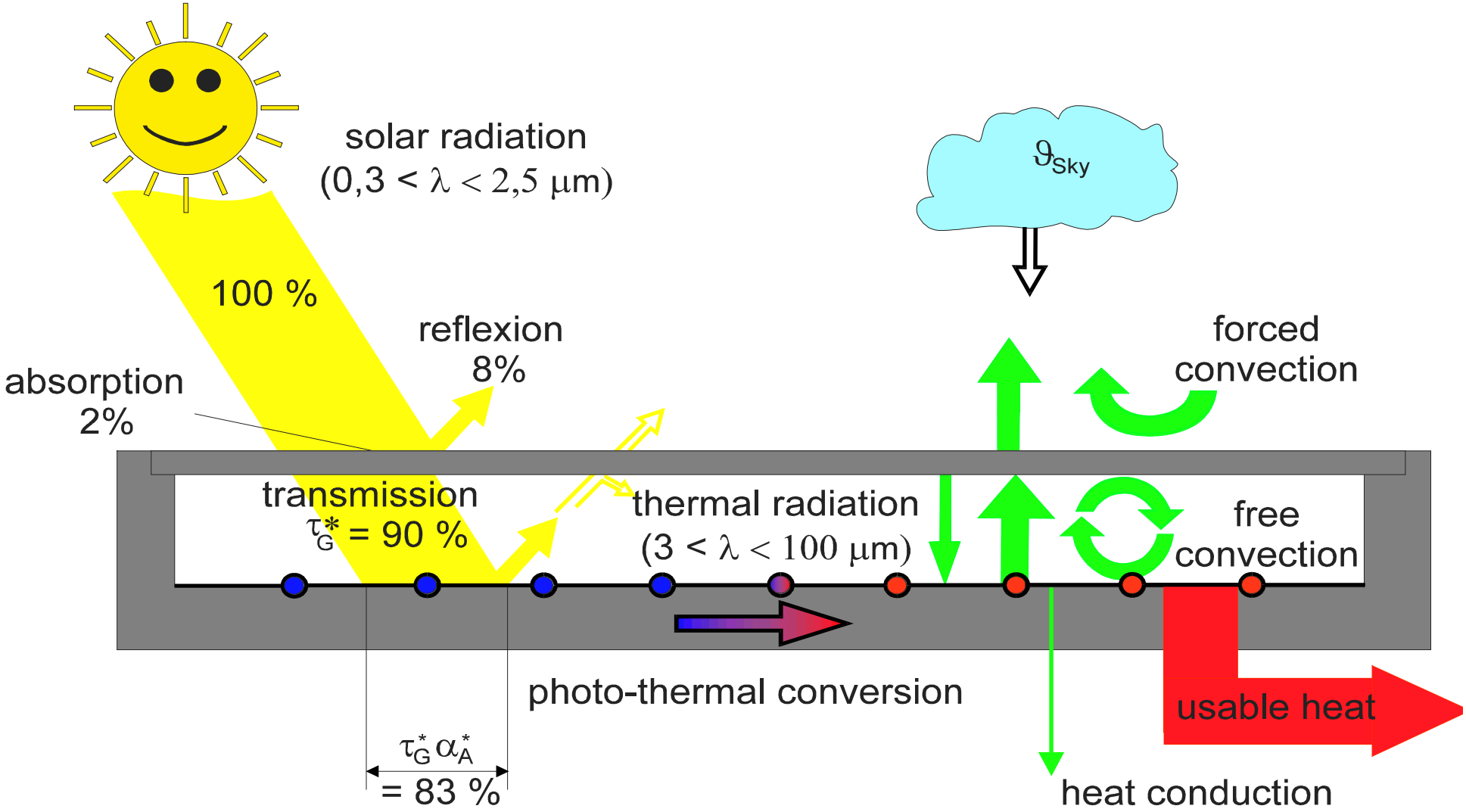
- selective or non-selective coating
- glass cover
  ⇒ reduction of thermal losses
- thermal insulation on backside
  ⇒ reduction of thermal losses
- typical range of operation 20 – 80°C



Source: Bosch Solarthermie GmbH

Flat plate collectors

Physical processes in a flat plate collector



Flat plate collectors

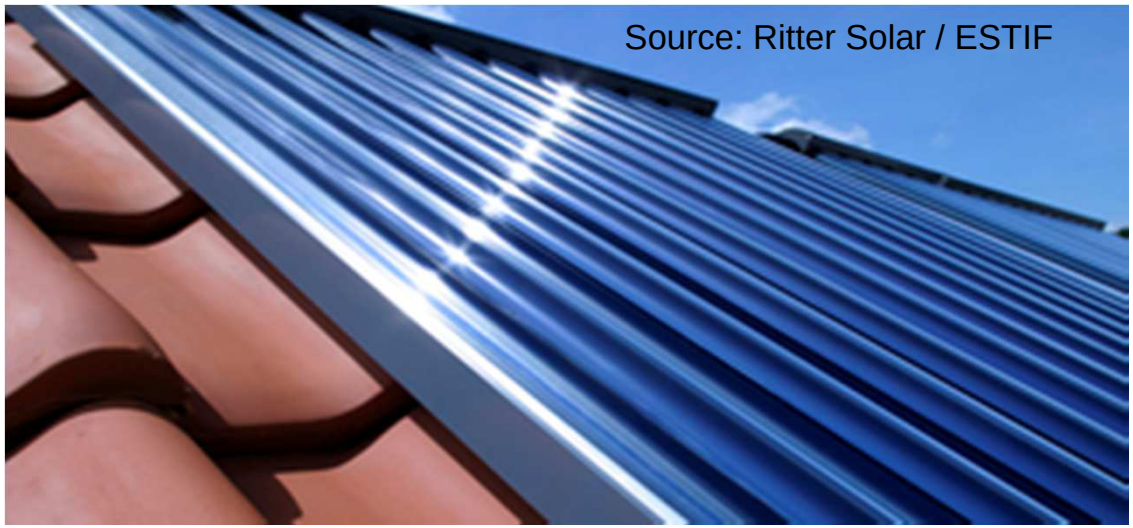
Size information

- modules available from approx. 1.5 to 12 m²
- typical collector area of a solar domestic hot water system (1 family house, Europe): 3 - 6 m²
- typical collector area of a solar combisystem (1 family house, Europe); 10 - 20 m²

Vacuum tube collectors

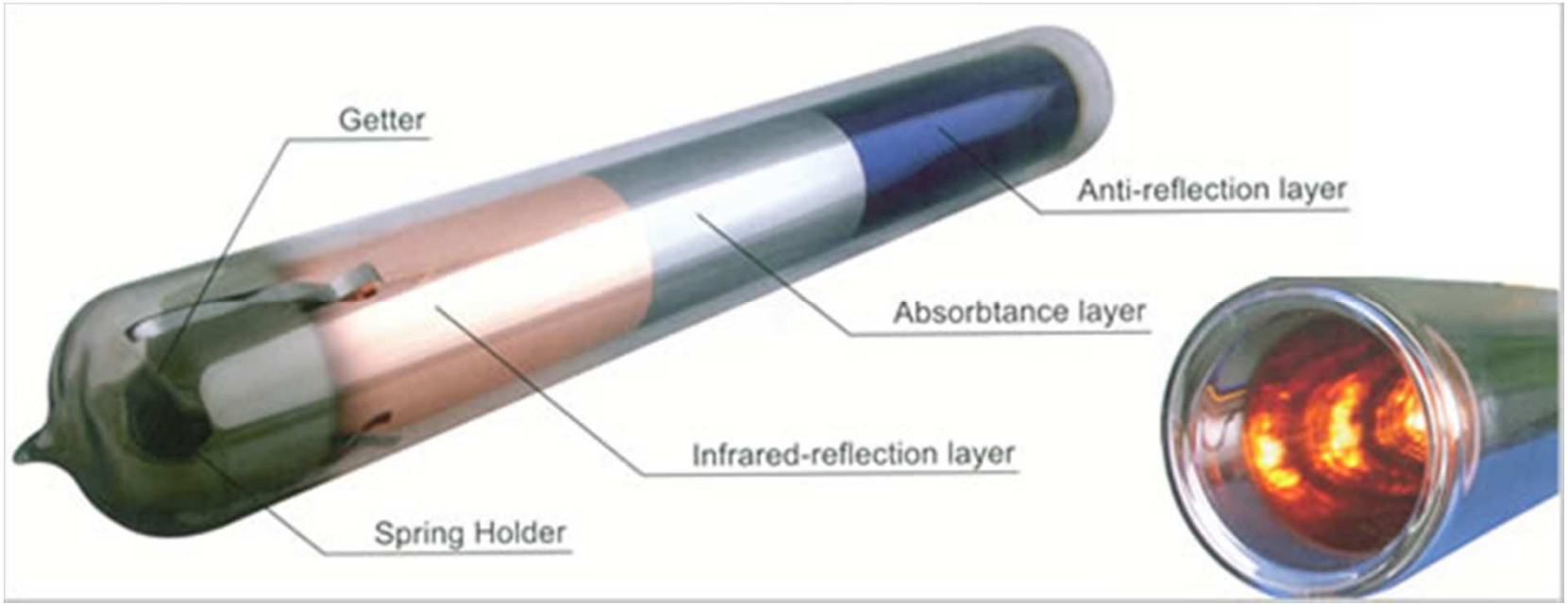
Features/advantages of vacuum tube collectors

- vacuum reduces heat losses
- efficiency nearly independent of ambient temperature
- more expensive than flat plate collectors



Sydney type evacuated tube

70 % of world wide collector market!

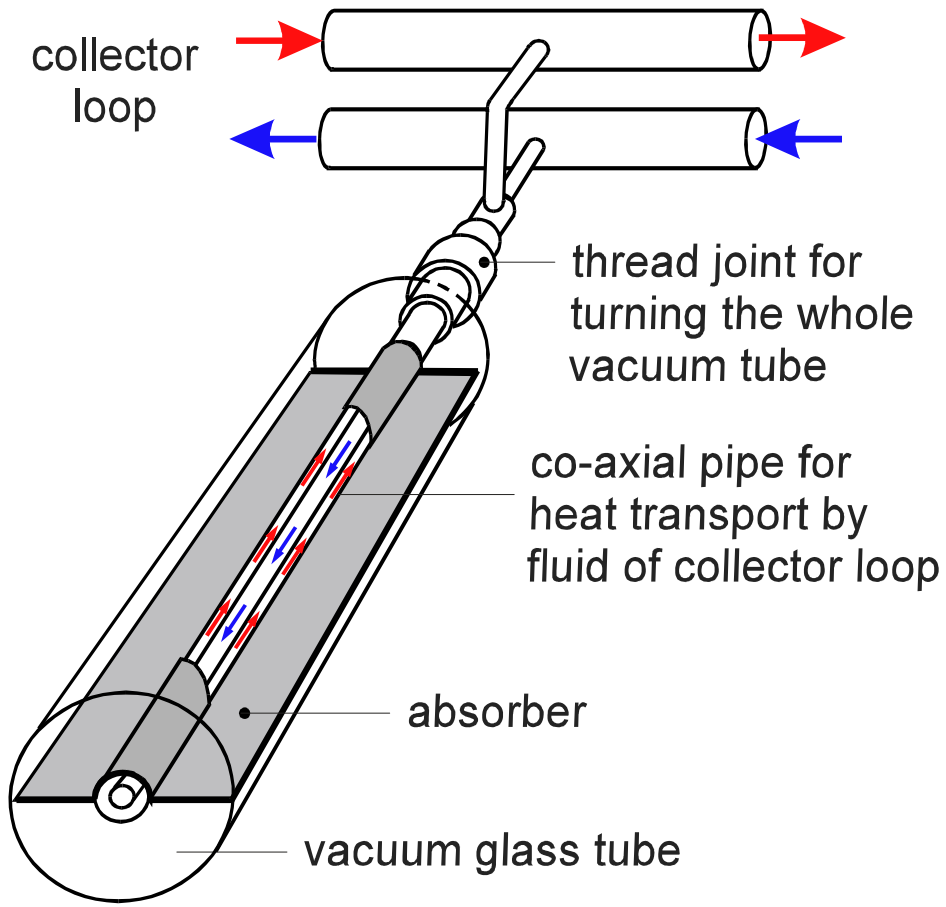


Source: surromax.com

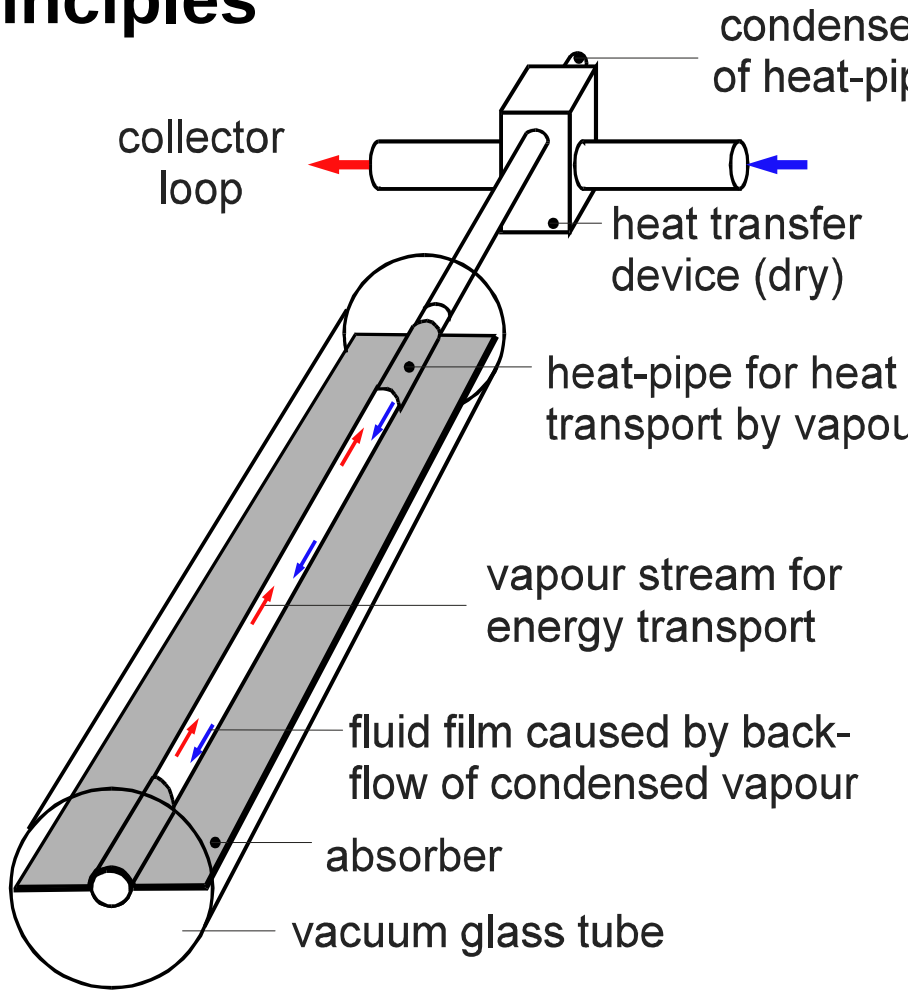
Details Sydney tube with U-pipe

Vacuum tube collectors

Different principles



vacuum tube
direct principle



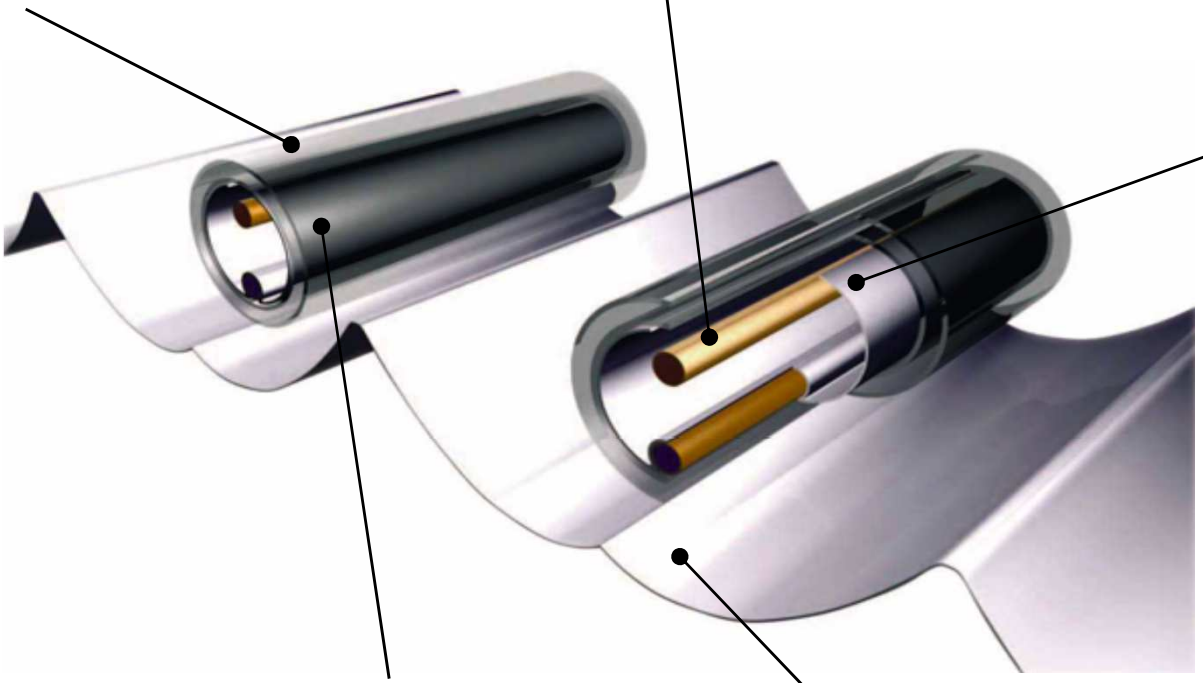
vacuum tube
heat-pipe principle

Vacuum tube collectors

Size information

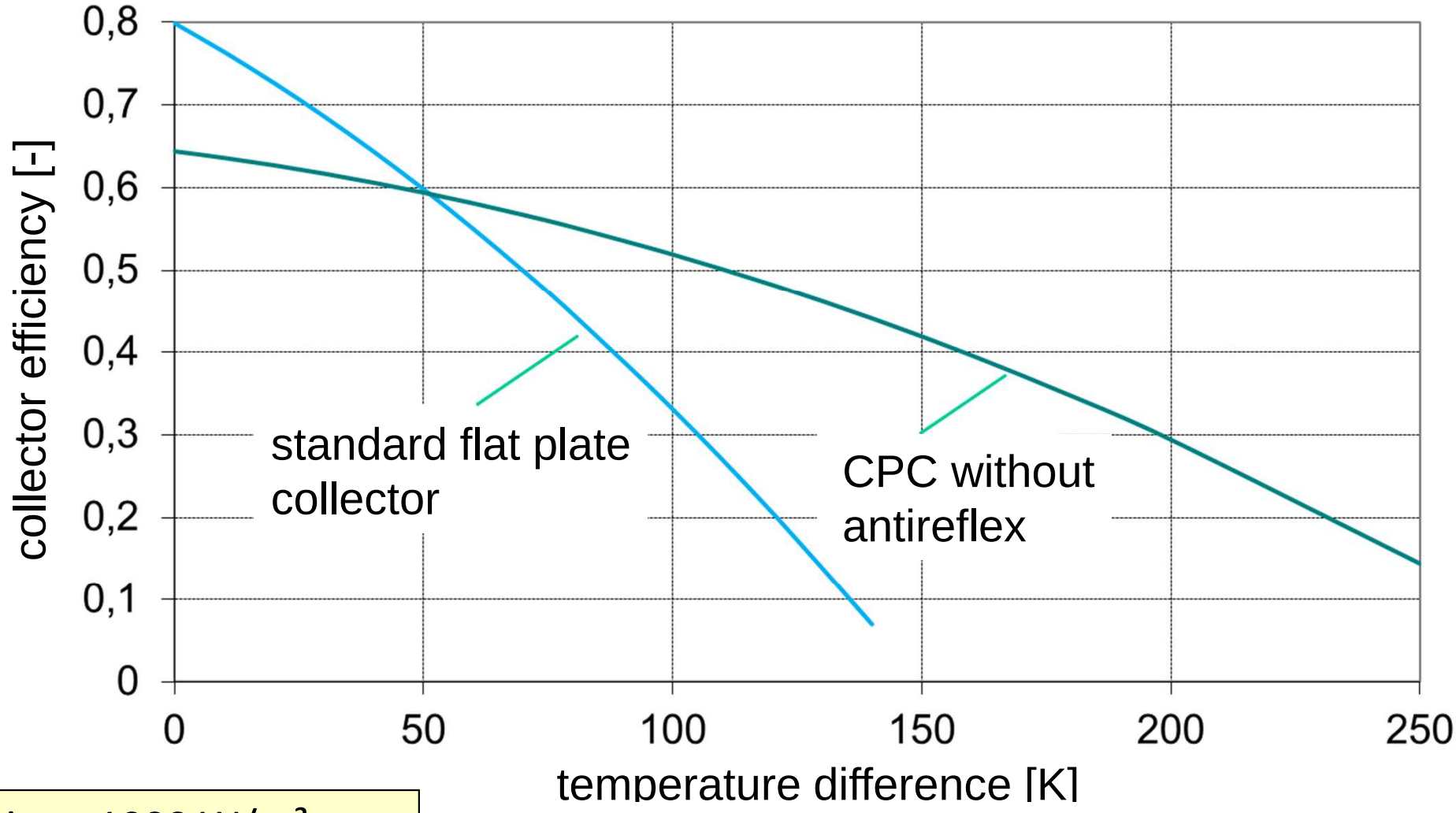
- smaller collector area (compared to flat plate collectors) needed because of higher efficiency
- typical collector area of a solar domestic hot water system (1 family house, Europe) 2.5 - 4 m²
- typical collector area of a solar combisystem (1 family house, Europe) 8 - 12 m²

Sydney type ETC with CPC



Source: Consolar GmbH

Collector efficiency curves



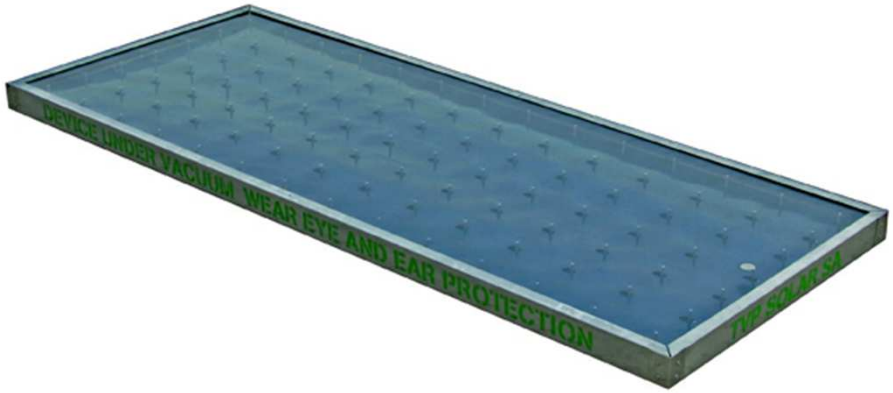
Radiation: 1000 W/m²

Examples of latest technological developments - solar collectors

Vacuum flat plate collector

Type MT-Power from
TVP-Solar

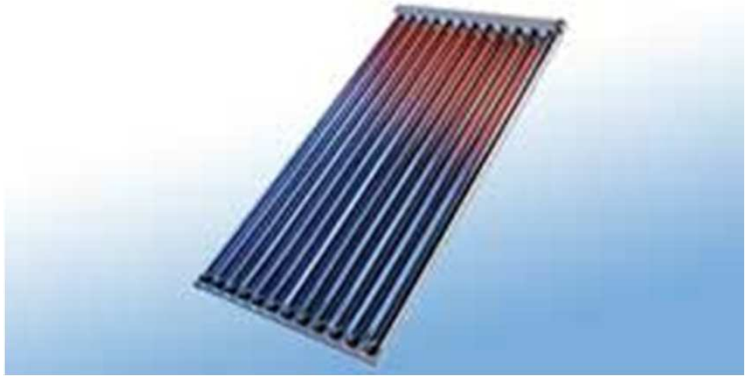
Source: www.tvpsolar.com



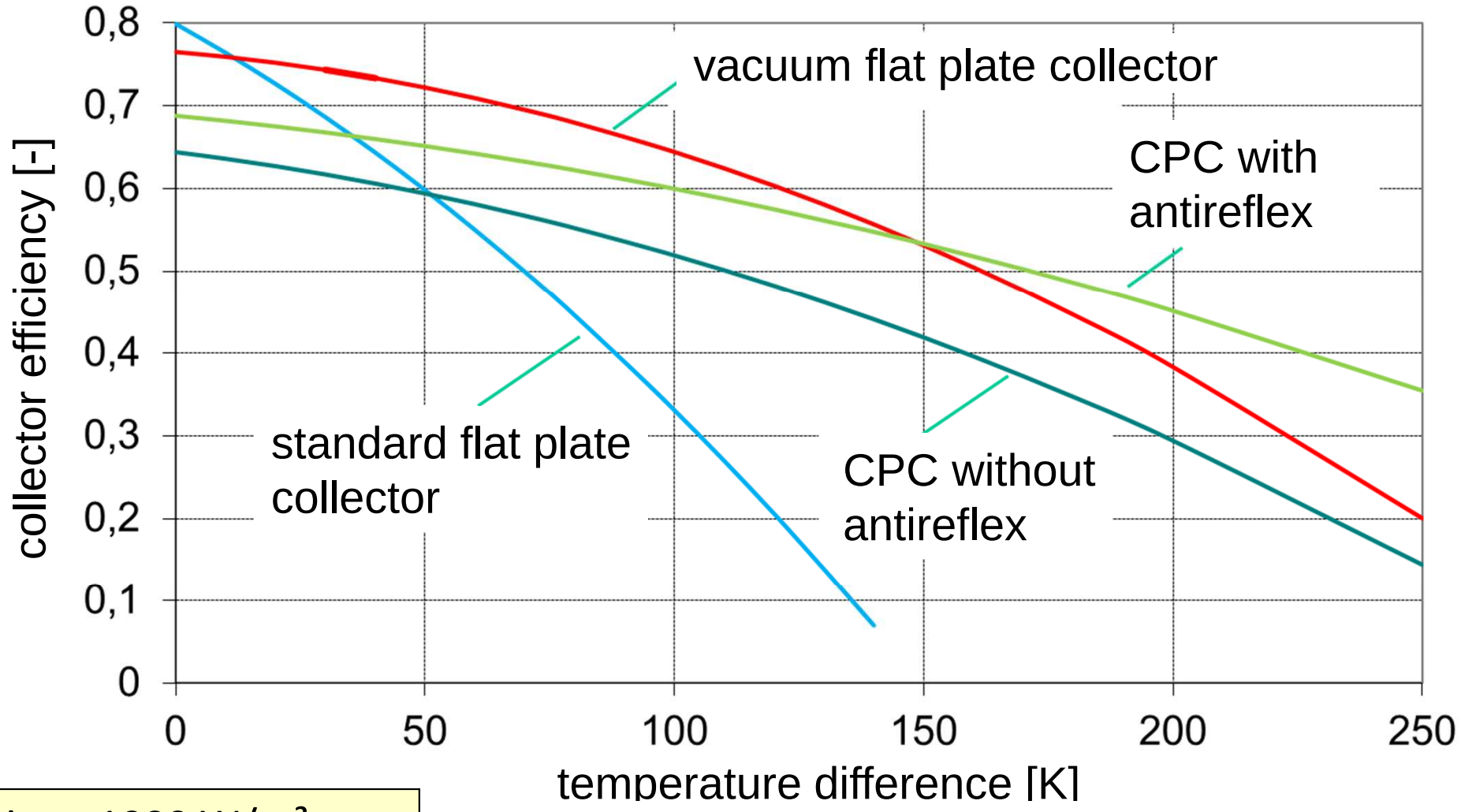
CPC collector with antireflective coating

Ritter Paradigma
CPC aqua plasma

Source: www.rittersolar.de



Collector efficiency curves



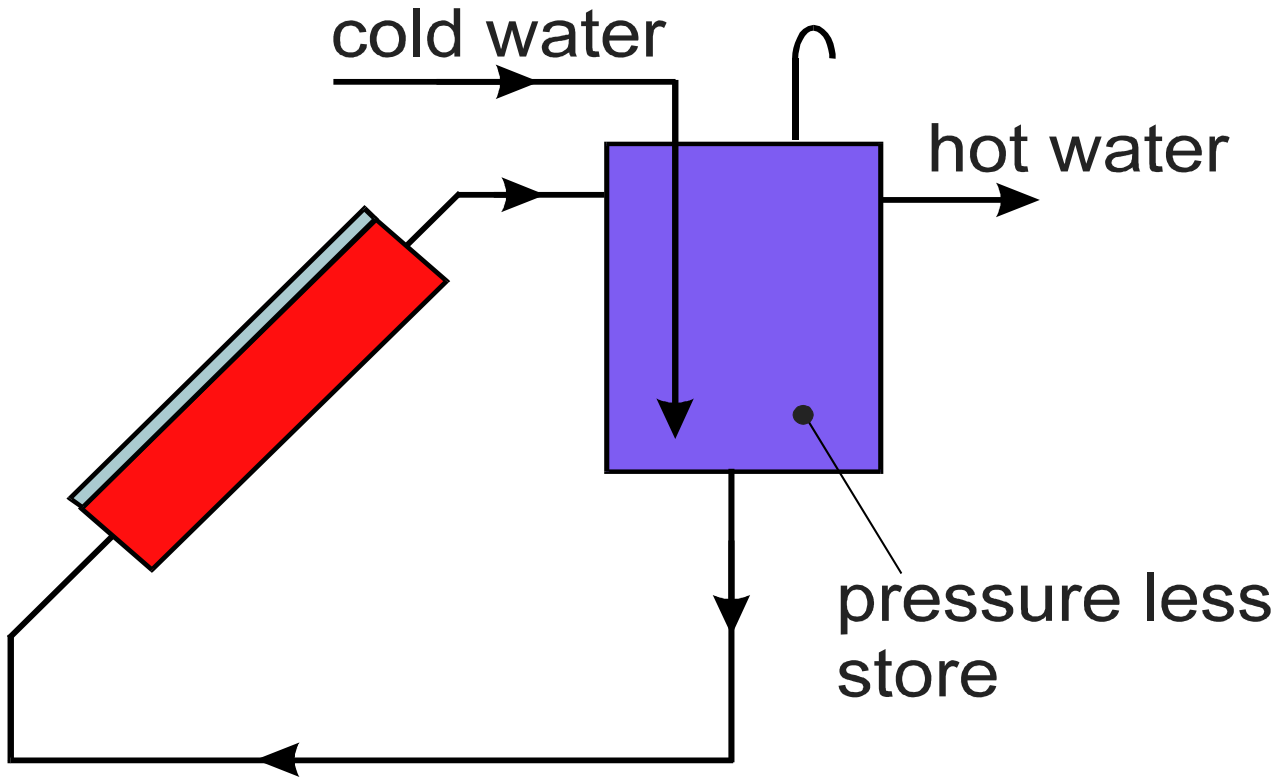
Radiation: 1000 W/m²

Three examples for solar thermal systems

Technologies to use solar thermal energy

- Solar thermal domestic hot water systems
  - » Thermosiphon systems
  - » Forced circulating systems
- Solar thermal combisystem

Thermosiphon Systems for Single Familiy Houses



direct thermosiphon system

Source: ELSE06\T_SIPH1E.CDR

Example for Thermosiphon System

Example for Thermosiphon System (China)

Source: AEE-INTEC, Werner Weiss

Thermosiphon Systems

Advantages:

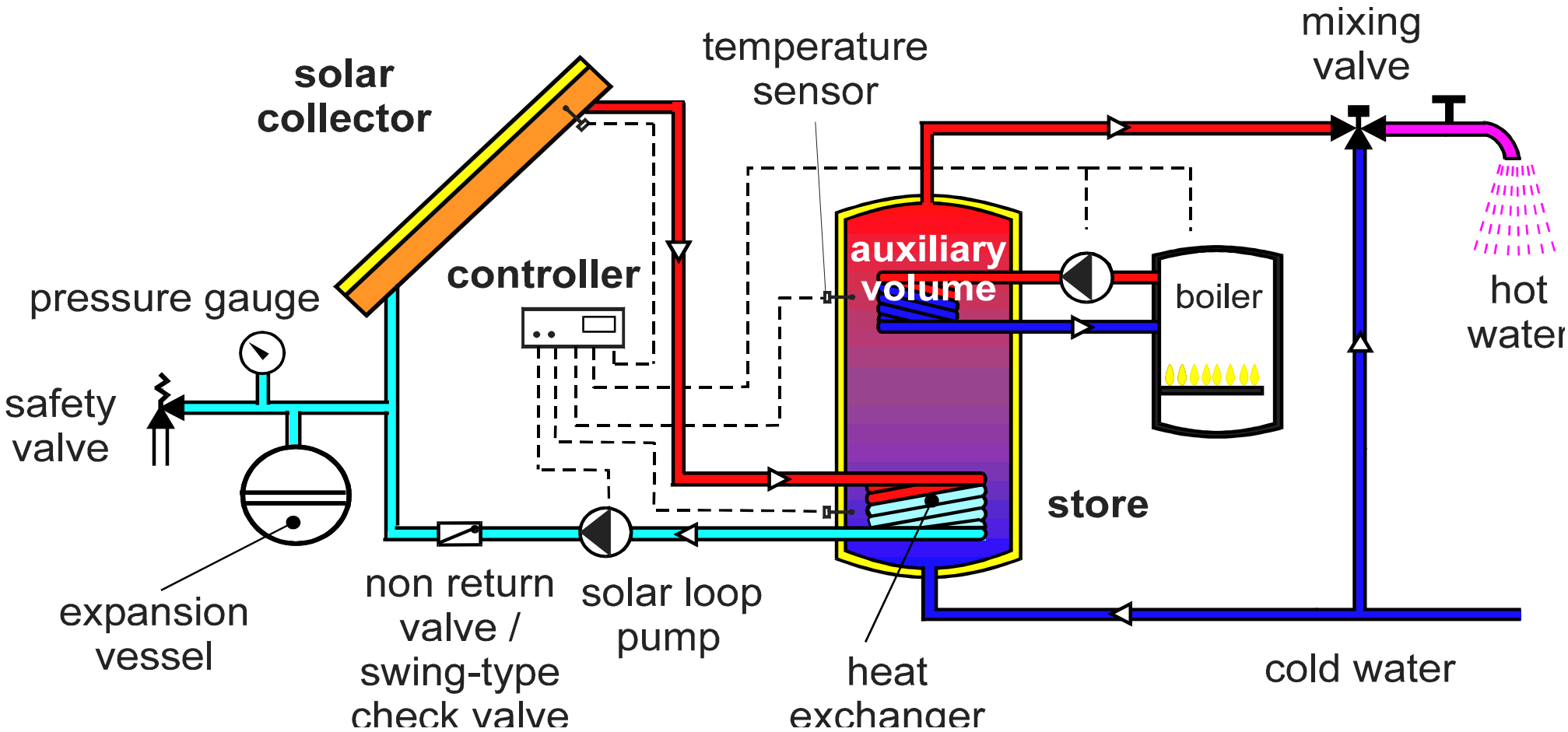
- very simple systems
- very efficient systems
- very cheap
- no electricity, no pump, no controller
- self controlling systems

Disadvantages:

- only applicable in regions without frost
- (aesthetic aspects)

Forced-circulating systems for single family houses

Detailed set-up of solar domestic hot water system



Dimensioning of solar domestic hot water systems for single family houses in Europe

- Collector area 1 m² to 1.5 m² per person

- Store volume approximately 50 - 70 l/m² collector area

---> annual solar fraction:
50 % - 70 % (of demand for DHW)

Performance Indicator f_{sol}

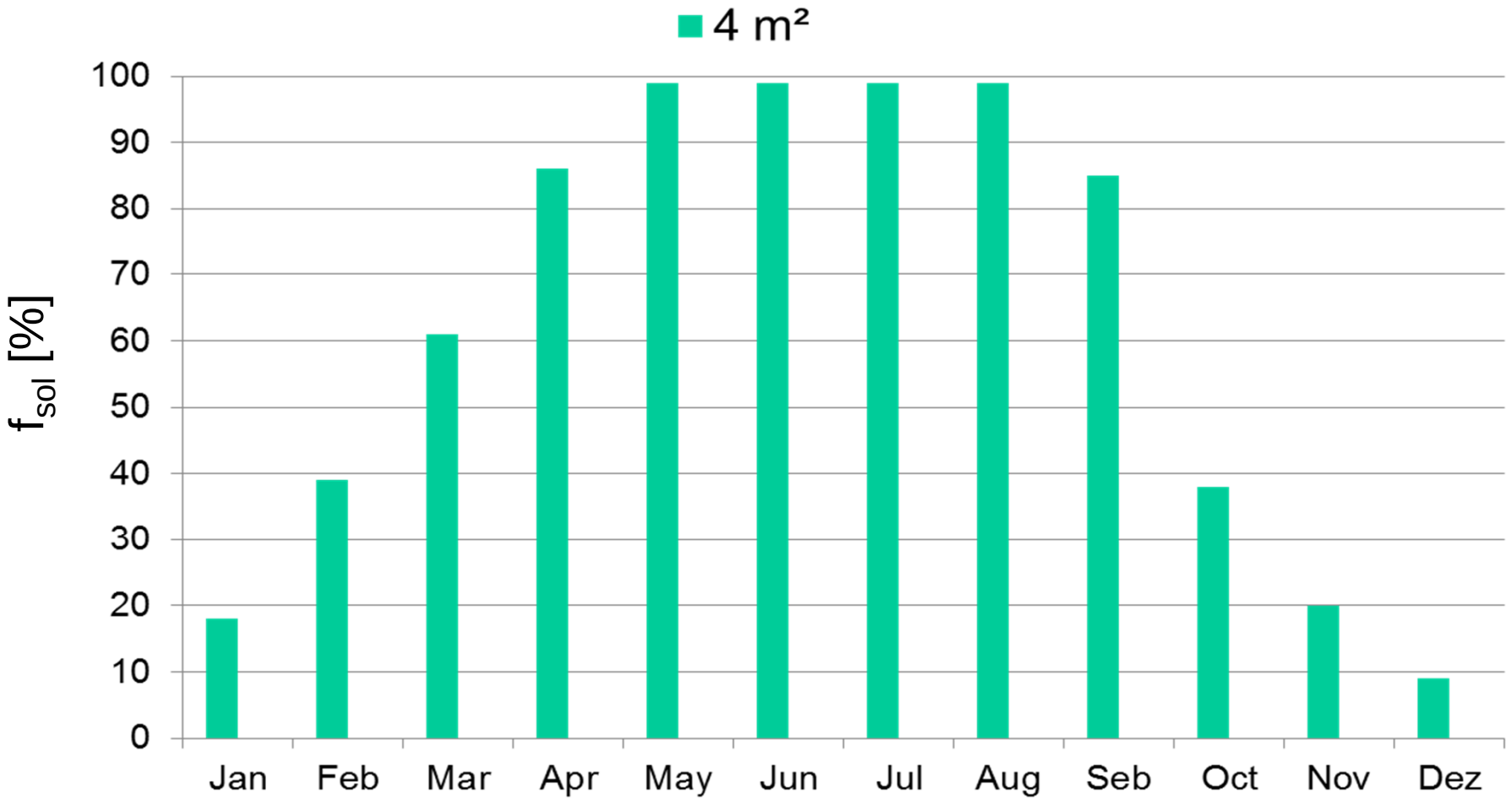
Solar Fraction f_{sol}
fractional reduction in the amount of energy that must be purchased

$$f_{sol} = \frac{Q_d - Q_{aux}}{Q_d}$$

Q_d : total heat demand for domestic hot water preparation and/or space heating

Q_{aux}: amount of energy from auxillary heater to fullfill the total heat demand

Energy savings of a typical solar domestic hot water system in a single family house (German conditions)



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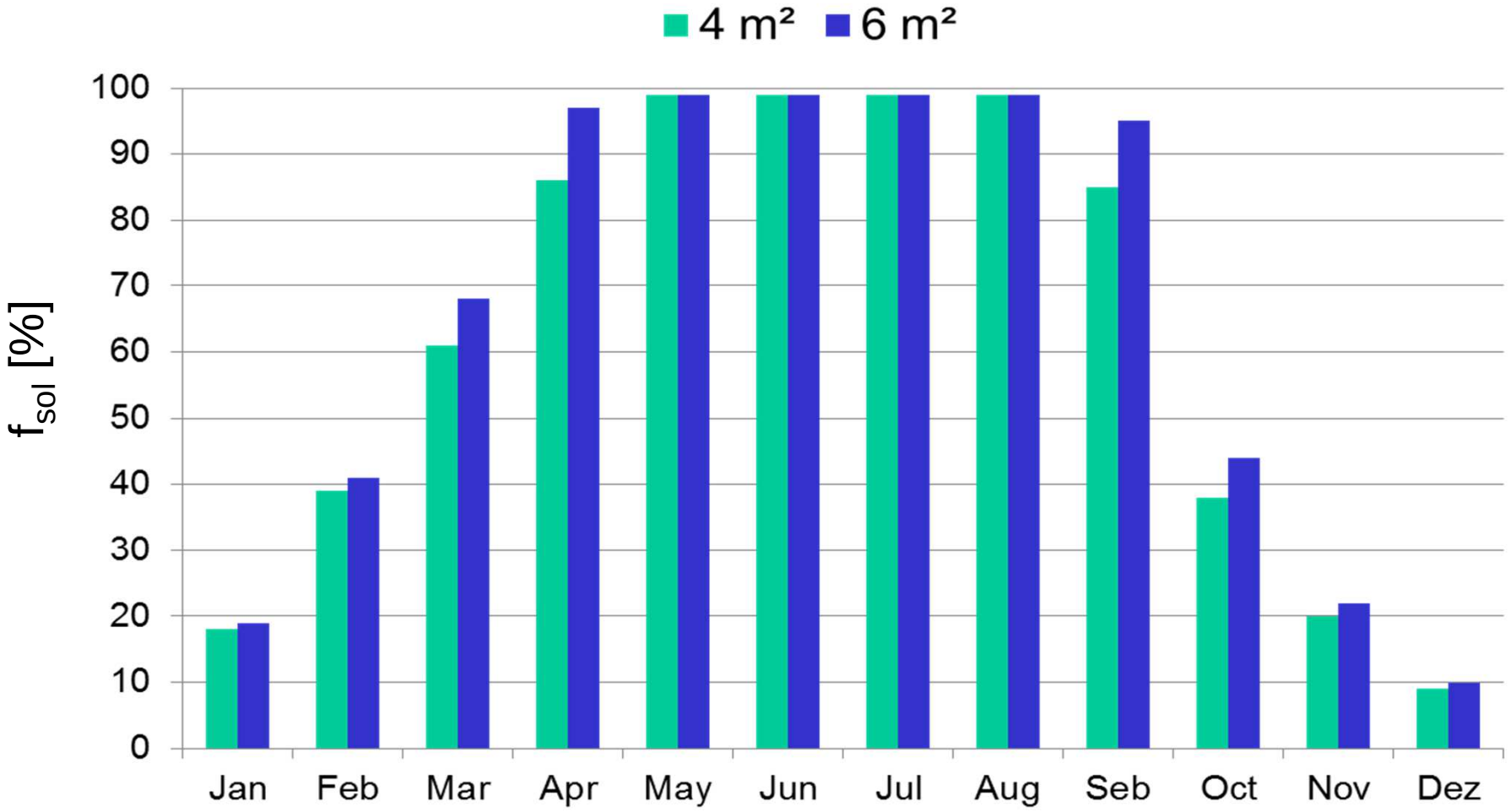
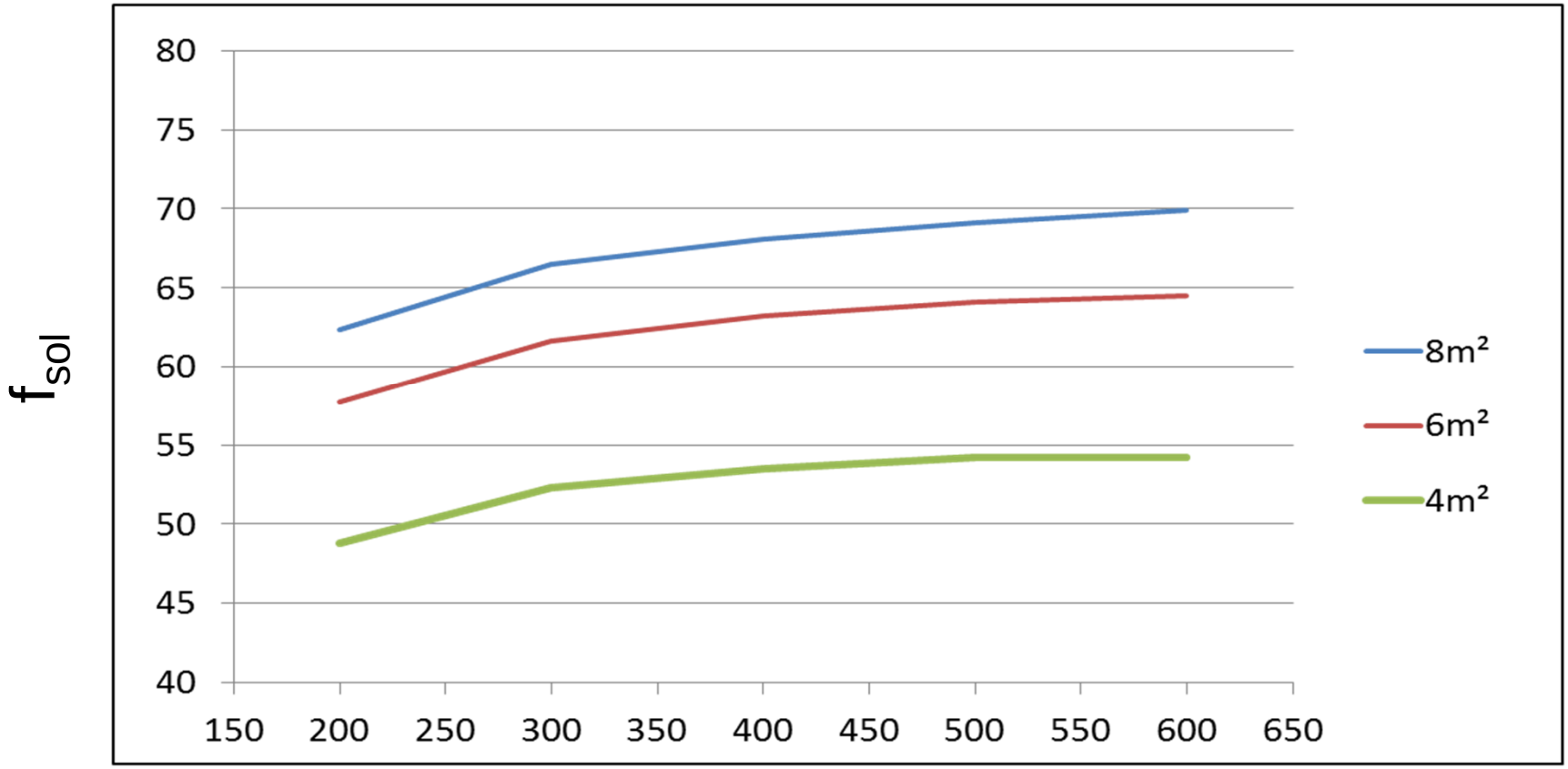


solar domestic hot water systems
effect of V_{sto} and Ac on f_{sol}

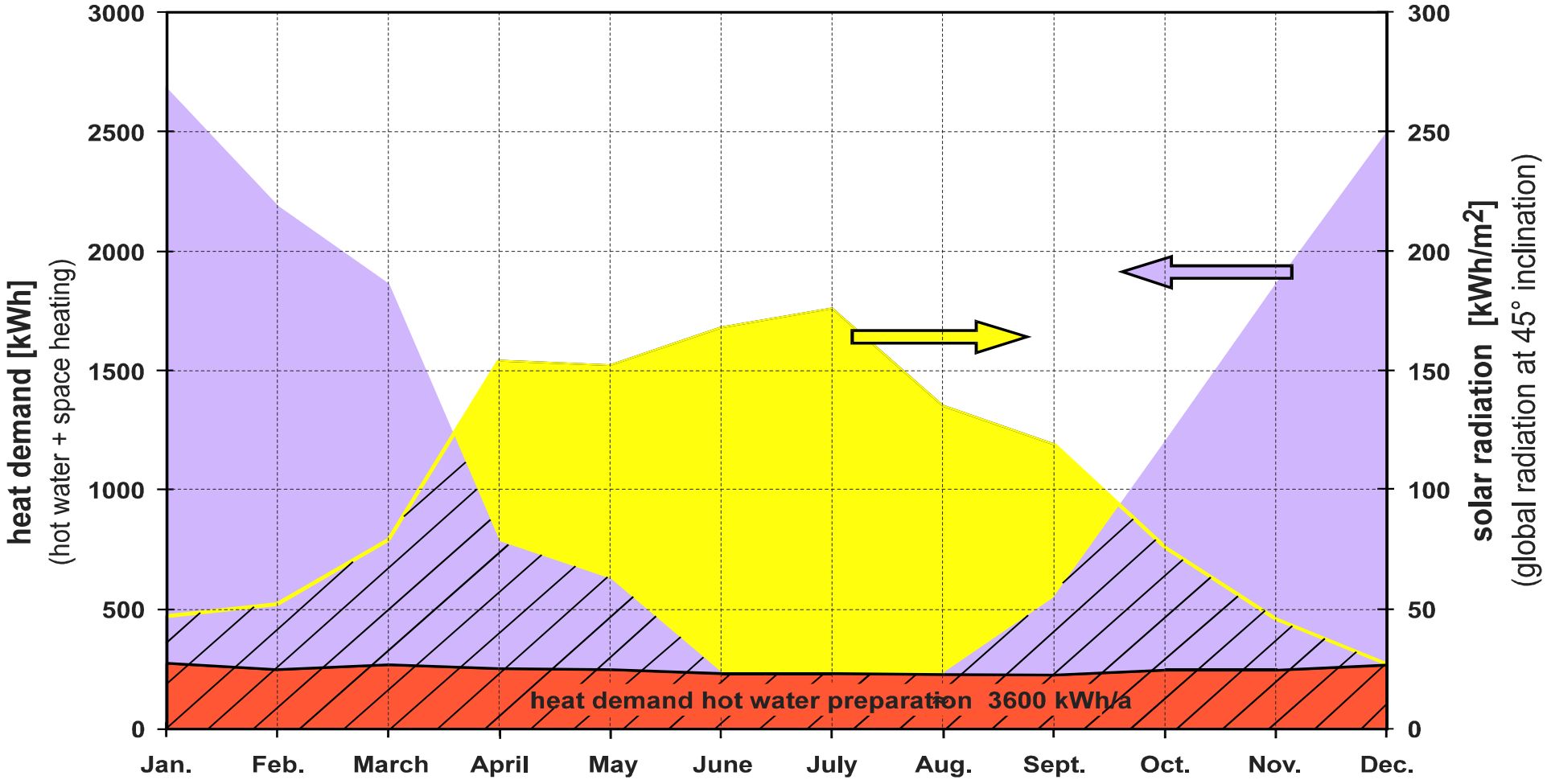


Solar thermal combisystems

Typical size of solar combisystems (Germany)

- 10 - 20 m² collector area
- 750 - 1500 l tank volume
- solar fraction 15 – 30% (of total heat demand)

Why is thermal energy storage a key technology for solar thermal systems?

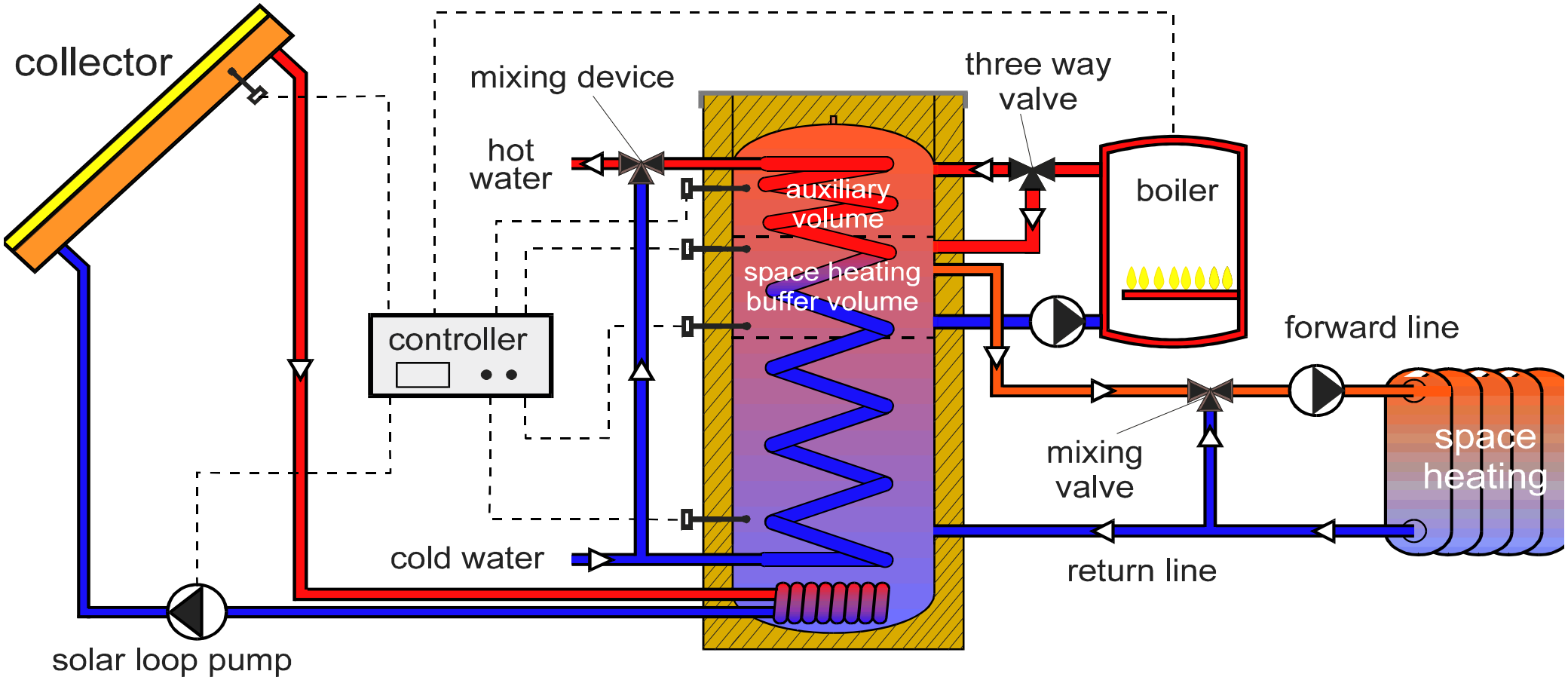


Solar thermal energy and thermal energy storage

- To make use of the solar energy supply in almost every solar thermal technology thermal energy storages play an important role
- Efficient solar thermal systems are closely linked to efficient energy storage

Solar combisystem

Schematic design



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Major differences between solar domestic hot water systems and solar combisystems

- different collector size
- different requirements on heat storage
  --> completely different storage designs
- different control strategies

Conclusions

- Technology for solar domestic hot water systems and solar combisystems is available
  - Suitable for new and retrofit applications
  - Small scale systems are state of the art
  - Design guidelines are available
  - Systems are cost-competitive
- Large scale heating and solar cooling systems and systems for industrial applications have a very high potential
- Additional advantage: Innovative technology, positive image, security of supply etc.

Unique advantages of solar thermal energy (ST)

- ST always leads to a direct reduction of primary energy consumption
- ST can be combined with nearly all kinds of back-up heat sources
- ST has the highest potential of all renewable energy sources and does not rely on finite resources, needed also for other energy and non-energy purposes
- ST does not lead to a significant increase in electricity demand, which could imply substantial investments to increase power generation and transmission capacities
- ST is available nearly everywhere. Current limitations, for instance at very high latitudes or in case of limited space for heat storage, can be largely overcome through R&D […]

Source: ESTTP – Solar Heating and Cooling for a Sustainable Energy Future in Europe

Unique advantages of solar thermal energy (ST)

- ST prices are highly predictable, since the largest part of them occur at the moment of investment, and therefore does not depend on future oil, gas, biomass, or electricity prices
- The life-cycle environmental impact of ST systems is extremely low
- ST replaces (mainly imported) natural sources with local jobs. Wherever the ST hardware will be produced in the future, a large portion of the value chain (distribution, planning, installation, maintenance) is inherently related to the demand side

Source: ESTTP – Solar Heating and Cooling for a Sustainable Energy Future in Europe

Thank you for your attention.

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